20 Torr pressure; O_2/SiH_4 gas ratio of 6:1. The reaction will work over a fairly wide range of O_2/SiH_4 gas ratios, but ratios in the 7-20:1 range provide highest deposition rates. The minimum substrate temperature for rapid deposition ~150 °C. The deposition reaction occurs minimally at 100 Torr with a SiH_4 gas flow rate of 30 sccm. Typical deposition rates are 200-300 angstroms/minute.

Example #7: Deep UV curing/resist stabilization

The scanning plasma reactor may be used in deep UV curing applications, where the surface of a photoresist layer is treated to a specific flux of UV photons, producing a cross-linking reaction that hardens the coating for subsequent processing, such as etching.

In practice, the photoresist coated wafer is processed through the reactor as it would be for any other application. The UV energy is set to a fluence in the range of about 20-75 mJ/cm^2, depending on the specific photoresist that is being cured. Since this is primarily a UV polymerization reaction, the gas used may be an inert gas such as argon or nitrogen. The gas that is selected may be determined by the specific photoresist used.

Other embodiments are within the scope of the claims. For example, the UV radiation can be injected over a range of incident angles in order to create special effects or to cause reactions to occur inside the intricate topography of the semiconductor wafer or other topographically structured surface.

What is claimed is:

1. A scanning plasma reactor for exciting or ionizing reactant gases with UV radiation at a substrate surface comprising:

a beam forming module to transform a UV radiation source raw output into a rectangular beam;

a gas injection module to deliver at least one reactant gas to the substrate surface;

a reaction chamber with a UV window through which said beam forming module projects said rectangular beam;

a vacuum chuck for holding a substrate; and

a gas exhaust module inside said chamber to remove reaction by-products and unreacted reactant gas from the substrate surface,

wherein said gas injection module and said gas exhaust module are in close proximity to said rectangular beam, and wherein said rectangular beam, said gas injection module and said gas exhaust module are movable relative to the substrate surface.

2. The scanning plasma reactor of claim 1 wherein said UV radiation source raw output is in the wavelength range of 351nm to 157nm.

3. The scanning plasma reactor of claim 1 wherein said rectangular beam has dimensions of approximately 200-300mm in length and 0.1-10mm in width.

4. The scanning plasma reactor of claim 1 wherein said rectangular beam has an energy level at the substrate surface in the range of about 0.1-10 Joules/cm^2.

5. The scanning plasma reactor of claim 1 wherein said beam forming module consists of a plurality of optical elements.

6. The scanning plasma reactor of claim 5 wherein said beam forming module consists of at least two cylindrical refractive elements.

7. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to create an etching reaction on the substrate surface.

8. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to create a deposition reaction on the substrate surface.

9. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to create an oxidation reaction on the substrate surface.

10. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to create a reduction reaction on the substrate surface.

11. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to create a melting reaction on the substrate surface.

12. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to modify the surface of a metallic or non-metallic film on the substrate surface.

13. The scanning plasma reactor of claim 1 wherein the reactant gases are combined with

the UV radiation to cause a polymerization or UV curing reaction on the substrate surface.

14. The scanning plasma reactor of claim 1, wherein said gas exhaust module comprises a block shaped manifold mounted at one end of the chamber to draws gas across the entire width of the chamber.

15. The scanning plasma reactor of claim 1, wherein said gas injection module and said gas exhaust module include adjustable slits which have a maximum length greater than the width of the substrate.

16. The scanning plasma reactor of claim 1, wherein said rectangular beam, said gas injection module and said gas exhaust module are moved across a stationary substrate surface.

17. The scanning plasma reactor of claim 1, wherein said rectangular beam, said gas injection module and said gas exhaust module are fixedly attached to the chamber and the substrate surface is moved.

18. The scanning plasma reactor of claim 1 wherein said rectangular beam is focused above the substrate surface to allow interaction with the reactant gas but prevent direct contact between said beam and the substrate surface.

19. The scanning plasma reactor of claim 1 wherein said gas injection module and said gas exhaust module are combined into a gas injection/exhaust system.

20. The scanning plasma reactor of claim 1 wherein said UV window is located on the top of the reaction chamber.

21. The scanning plasma reactor of claim 1 wherein said UV window is located on one side of the reaction chamber.

22. The scanning plasma reactor of claim 1 wherein said reaction chamber is at atmospheric pressure.

23. The scanning plasma reactor of claim 1 further comprising an electronic control module to programmably select a reactant gas chemistry and an excitation energy level for one or more processes selected from etching, deposition, doping, ion implantation, re-crystallization, UV curing, oxidation, surface roughening, photochemical modification, and reduction reactions.

24. The scanning plasma reactor of claim 1 wherein the substrate surface is transparent to said rectangular beam and said rectangular beam causes a reaction at a layer of the substrate below the substrate surface.

25. The scanning plasma reactor of claim 1 wherein the reactant gases are reacted to create a doping reaction on the substrate surface.

26. The scanning plasma reactor of claim 1 wherein said vacuum chuck includes a heating element to heat the substrate.

27. The scanning plasma reactor of claim 1 wherein said beam forming module includes a mirror which is adjustably positionable to change the angle of said rectangular beam relative to the substrate surface.

Docket No. UV-102J

28. A scanning plasma reactor for exciting or ionizing reactant gases with UV radiation at a substrate surface comprising:

a beam forming module to transform a UV radiation source raw output into a rectangular beam;

a gas injection module to deliver at least one reactant gas to the substrate surface;

a reaction chamber with a UV window through which said beam forming module projects said rectangular beam; and

a gas exhaust module inside said chamber to remove reaction by-products and unreacted reactant gas from the substrate surface,

wherein said gas injection module is fixed at one end of said chamber and said gas exhaust module is fixed at an opposite end of said chamber relative to said gas injection module and said rectangular beam is movable relative to the substrate surface.

29. A scanning plasma reactor for exciting or ionizing reactant gases with UV radiation at a substrate surface comprising:

a beam forming module to transform a UV radiation source raw output into a rectangular beam;

a gas injection module to deliver at least one reactant gas and at least a second fluid or vapor to the substrate surface;

a reaction chamber with a UV window through which said beam forming module projects said rectangular beam; and

a gas exhaust module inside said chamber to remove reaction by-products and unreacted reactant gas from the substrate surface,

wherein said rectangular beam and said at least one reactant gas form a reaction zone at or near the substrate surface, said reaction zone being movable relative the substrate.

30. A scanning plasma reactor for exciting or ionizing reactant gases with radiation at a substrate surface comprising:

a first beam forming module to transform a first radiation source raw output into a first rectangular beam;

a second beam forming module to transform a second radiation source raw output into a second rectangular beam;

a gas injection module to deliver at least one reactant gas to the substrate surface;

a reaction chamber with at least one window through which said first and second beam forming modules project said first and second rectangular beams; and

a gas exhaust module inside said chamber to remove reaction by-products and unreacted reactant gas from the substrate surface,

wherein said first and second rectangular beams and said at least one reactant gas form a reaction zone, said reaction zone being moveable relative to the substrate surface.

31. The scanning plasma reactor of claim 30 wherein said first rectangular beam is UV radiation.

32. The scanning plasma reactor of claim 30 wherein said second rectangular beam is infrared radiation.

33. The scanning plasma reactor of claim 30 wherein said reaction chamber has a first window in the top surface of said reaction chamber through which first beam forming module projects said first rectangular beam and has a second window in one side of said

reaction chamber through which second beam forming module projects said second rectangular beam.

Page 31 of 36